

# IMAGE PROCESSING APPARATUS AND IMAGE PROCESSING METHOD

## CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on application No. 2002-271511 filed in Japan, the contents of which is hereby incorporated by reference.

## BACKGROUND OF THE INVENTION

### FIELD OF THE INVENTION

[0002] The present invention relates to an image processing apparatus that performs image processing, and more particularly, to an image processing apparatus that distinguishes image attributes, particularly halftone-dot regions, and performs image processing appropriate for such attributes.

## DESCRIPTION OF THE RELATED ART

[0003] In the conventional art, when image processing apparatuses such as printers perform printing or other processing of halftone-dot regions, the phenomenon of moiré can occur. As a result, the occurrence of moiré has been prevented by extracting halftone-dot regions from the image data and carrying out smoothing regarding the extracted halftone-dot regions. As a process for extracting halftone-dot regions from image data, a process has been proposed wherein the image data is divided into blocks having a prescribed range and it is determined whether the characteristics of each block correspond to

those of a halftone-dot region (Japanese Laid-Open Patent Application 2002-27242).

[0004] However, the following problem exists in connection with the conventional image processing apparatus described above. Namely, the image data may include figures that are determined to be isolated points, depending on the character configuration. In particular, in the case of small-sized characters (particularly characters that are 5-point or smaller), areas bordered by lines can be detected as white isolated points. Furthermore, the dot in the letter 'i' or the small lines at the bottom in such characters as the Japanese character '焦' may be detected as black isolated points. In addition, a dot formed by the intersection of lines may also be detected as a black isolated point. A region in which these characters are concentrated may be incorrectly determined to be a halftone-dot region even if it is not. Furthermore, because smoothing is carried out to such erroneously determined regions, the sharpness of the characters contained therein may deteriorate.

[0005] Specifically, in a halftone-dot region in which isolated points are distributed evenly as shown in Fig. 7, 12 isolated points are extracted from the block shown in Fig. 7. On the other hand, in a character region, three of the characters '田' in a small point size may be concentrated in a single block, as shown in Fig. 8. In this situation, four white isolated points are extracted for each character '田'. Consequently, from this character region, a total of 12 isolated points are extracted from the three characters. As a result, when the determination

of whether or not a halftone-dot region exists is based on the number of isolated points, because the block in Fig. 8 contains the same number of isolated points as the halftone-dot region in Fig. 7, it is erroneously determined to be a halftone-dot region even though it is in fact a character region.

#### OBJECTS AND SUMMARY

[0006] The present invention was created in order to resolve the problem with the technology of the prior art identified above. In other words, an object of the present invention is to provide an image processing apparatus that minimizes deterioration in output image quality by appropriately distinguishing the attributes of image areas, particularly halftone-dot regions, and performing processing properly suited to such areas.

[0007] The image processing apparatus constituting a first aspect of the present invention is an image processing apparatus that handles image data, comprising a dividing unit which divides image data into large blocks of a prescribed size and further subdivides these large blocks into multiple smaller blocks; a large block isolated point calculation unit which calculates the number of isolated points contained in each large block established by the dividing unit; a small block isolated point calculation unit which calculate the number of isolated points contained in each small block established by the dividing unit; and a halftone-dot region determination unit which determines whether or not a large block is a halftone-dot region based on the number of isolated points calculated

by the large block isolated point calculation unit and the number of the isolated points calculated by the small block isolated point calculation unit.

[0008] In this image processing apparatus, the large blocks are subdivided by the dividing unit into small blocks. The number of isolated points in each large block is then calculated by the large block isolated point calculation unit, and the number of isolated points in each small block is then calculated by the small block isolated point calculation units. It is then determined by the halftone-dot region determination unit whether or not the large block is a halftone-dot region. This determination considers both the number of isolated points in the large block and the number of isolated points in each small block. In other words, for a large block to be determined a halftone-dot region, not only must the number of isolated points in the large block satisfy the condition for determination as a halftone-dot region, but the number of isolated points in each small block must also satisfy the condition for a halftone-dot region. This allows region attributes to be distinguished in more detail and reduces the risk of an erroneous region attribute determination.

[0009] The image processing apparatus of a second aspect of the present invention is an image processing apparatus that handles image data, comprising: a dividing unit which divides image data into multiple small blocks; a small block isolated point calculation unit which calculate the number of isolated points contained in each small block established by the dividing unit; a large block isolated point calculation unit which calculates the number of

isolated points contained in the large block composed of multiple smaller blocks based on the small block isolated point totals calculated by the small block isolated point calculation units; and a halftone-dot region determination unit which determines whether or not a large block is a halftone-dot region based on the number of isolated points calculated by the large block isolated point calculation unit and the number of isolated points calculated by the small block isolated point calculation unit. The effect described above can be obtained in this case as well.

[0010] Furthermore, in these aspects of the present invention, it is preferred that the halftone-dot region determination unit determine that a large block is a halftone-dot region if the number of isolated points in the large block equals or exceeds a first prescribed value and the number of isolated points in each small block contained in the large block equals or exceeds a second prescribed value. Where a large block is a halftone-dot region, the isolated points are often evenly distributed. On the other hand, in the case of character regions, it is extremely rare for the isolated points to be evenly distributed. In other words, the halftone-dot region determination unit appropriately extracts halftone-dot regions based on such characteristics. Incidentally, the second prescribed value is smaller than the first prescribed value.

[0011] The image processing method of a third aspect of the present invention is an image processing method that handles image data and includes the following steps: (1) dividing image data into large blocks of a prescribed

size and further subdividing these large blocks into multiple smaller blocks; (2) calculating the number of isolated points contained in the large block established via division and the number of isolated points contained in the small block established via division; and (3) determining whether or not the large block is a halftone-dot region based on the calculated number of large block isolated points and the calculated number of small block isolated points.

[0012] The image processing method of a fourth aspect of the present invention is an image processing method that handles image data and includes the following steps: (1) dividing image data into multiple small blocks; (2) calculating the number of isolated points contained in each small block established via division; (3) calculating the number of isolated points contained in the large block composed of multiple smaller blocks based on the calculated number of small block isolated points; and (4) determining whether or not the large block is a halftone-dot region based on the calculated number of large block isolated points and the calculated number of small block isolated points.

[0013] These and objects, advantages and features of the invention will become apparent from the following description thereof taken in conjunction with the accompanying drawings which illustrate specific embodiments of the invention.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Fig. 1 is a block diagram showing the functions

of an image processing apparatus of an embodiment of the present invention;

[0015] Fig. 2 is a block diagram showing the functions of a halftone-dot determination unit;

[0016] Fig. 3 is a conceptual drawing showing a large block and small blocks in a halftone-dot region;

[0017] Fig. 4 is a conceptual drawing showing a large block and small blocks in a character region;

[0018] Fig. 5 is a flow chart of the operations executed by the halftone-dot determination unit;

[0019] Fig. 6 is a flow chart of the isolated point counting operation;

[0020] Fig. 7 is a drawing showing the isolated points in a halftone-dot region according to the conventional art; and

[0021] Fig. 8 is a drawing showing the isolated points in a character region according to the conventional art.

[0022] In the following description, like parts are designated by like reference numbers throughout the several drawings.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0023] A specific embodiment of the image processing apparatus pertaining to the present invention will be explained below with reference to the drawings. This embodiment takes the form of an image forming apparatus. The image processing apparatus of this embodiment has a color conversion unit 1, a region determination unit 2, an edge reproduction unit 5 and an image forming engine 6, as shown in Fig. 1. The region determination unit 2

has a character determination unit 3 and a halftone-dot determination unit 4. The color conversion unit 1, character determination unit 3 and halftone-dot determination unit 4 receive input of image data.

[0024] The various constituent components shown in Fig. 1 will now be described. The color conversion unit 1 converts input image data from RGB input system signals to CMYK output system signals, for example. At the same time, the region determination unit 2 determines the attributes of the regions comprising the input image data. The character determination unit 3 of the region determination unit 2 determines the existence of character regions (regions containing fine lines) in the input image data and generates a signal for each pixel indicating whether or not the pixel is a character region. Similarly, the halftone-dot determination unit 4 of the region determination unit 2 determines the existence of halftone-dot regions and generates signals indicating whether or not each pixel is a halftone-dot region. The edge reproduction unit 5 carries out correction processing such as edge enhancement and smoothing to the image data output by the color conversion unit 1 in accordance with the signals output from the region determination unit 2. The image forming engine 6 forms images on a medium such as paper based on the image data output by the edge reproduction unit 5. The image forming engine 6 may use any method to form images based on image data, including the electrophotographic method that employs a photosensitive body and toner or the inkjet method.

[0025] The halftone-dot determination unit 4 will now



be described. As shown in Fig. 2, the halftone-dot determination unit 4 includes a dividing unit 40, isolated point counters 41, 42, 43, 44 and 45, an adder 46, a comparator 47, an OR circuit 48 and an AND circuit 49. The dividing unit 40 divides the image area into blocks (hereinafter termed 'large blocks') having a size of  $M \times N$  pixels, and further divides these large blocks into smaller blocks (hereinafter termed 'small blocks') having a size of  $(i) \times (j)$  pixels. The isolated point counters each count the number of isolated points in a small block. The adder 46 adds up the total number of isolated points counted by the isolated point counters 41-45 and deems this number the number of isolated points in a large block. The comparator 47 compares the number of large block isolated points with a threshold value. The image processing apparatus of this embodiment divides the large block into five small blocks ① through ⑤, and includes the isolated point counters 41-45 that correspond to these small blocks. The sizes of the small and large blocks may be set appropriately in accordance with the type of halftone-dot region to be detected. For example, the small blocks may be set at  $5 \times 5$  pixels and the large blocks set at  $5 \times 25$  pixels.

[0026] The operation of the halftone-dot determination unit 4 will now be described. First, the image data is sent to the dividing unit 40. The sent image data is divided into large blocks by the dividing unit 40. The large blocks are then further divided into five small blocks. In other words, each large block is divided into five contiguous small blocks ① through ⑤ by being divided into five sections

as shown in Fig. 3. The image data for each small block is sent to the isolated point counter 41-45 corresponding to that small block.

[0027] The number of isolated points is counted for each region by the respective isolated point counters 41-45 and the number of isolated points is obtained for each region. For example, for the image data shown in Fig. 3, the number of isolated points in the small block ① is counted by the isolated point counter 41. Because three isolated points exist in the small block ①, the number of isolated points in the small block ① is '3'. The number of small block isolated points obtained by the five isolated point counters is then sent to the adder 46 and the OR circuit 48.

[0028] The total number of isolated points in the small blocks ① through ⑤ is then calculated by the adder 46, and the number of isolated points in the large block is thereby obtained. For example, for the image data shown in Fig. 3, the two or three isolated points present in each of the small blocks are counted by the corresponding isolated point counter, and the total of twelve is obtained as the number of isolated points in the large block. This number of large block isolated points is then sent to the comparator 47.

[0029] The comparator 47 compares the number of large block isolated points that it has received with a prescribed threshold value. If the number of large block isolated points exceeds the threshold value, the comparator 47 sends an 'H' signal to the AND circuit 49, while if the number of large block isolated points is less than the threshold

value, the comparator 47 sends an 'L' signal to the AND circuit 49.

[0030] If the output value from all of the isolated point counters 41-45 is '0', the OR circuit 48 outputs an 'L' signal to the AND circuit 49, while if any other value is obtained, OR circuit 48 outputs an 'H' signal to the AND circuit 49. In other words, where the input number of isolated points is expressed as a binary number, if any '1' component is contained in the binary number, 'H' is output. Therefore, if no isolated points exist in the small block, 'L' is output, while if even one isolated point is counted, 'H' is output. In addition, the OR circuit 48 performs calculation for each isolated point counter (small block) and sends the result to the AND circuit 49.

[0031] Next, a halftone-dot region signal is output by the AND circuit 49 based on the output result from the OR circuit 48 and the output result from the comparator 47. Specifically, where the output value from the comparator 47 is 'H' and all values output from the OR circuit 48 are 'H', a halftone-dot region signal indicating that the region constituting this large block is a halftone-dot region is output. Here, in the case of a halftone-dot region, there is a high probability that the isolated points in an area of at least a certain size will be distributed evenly within that area, as shown in the image of Fig. 3. On the other hand, in the case of a character region, it is extremely unlikely that the isolated points in an area of at least a certain size will be distributed evenly within that area, and even in an area having contiguous characters, such an even distribution over a

large area is highly unlikely, as shown in the image of Fig. 4. In other words, the halftone-dot determination unit 4 extracts halftone-dot regions based on these region characteristics.

[0032] A specific example will be described based on the image data shown in Fig. 3 (halftone-dot region) and Fig. 4 (character region). Here, the threshold value to which the number of large block isolated points is compared (used by the comparator 47 in Fig. 2) is a number smaller than 12. First, in the image data shown in Fig. 3, there are 12 isolated points in the large block, and 'H' is output by the comparator 47. Furthermore, two or three isolated points are present in each small block, and the values output from the OR circuit 48 are all 'H'. Therefore, a halftone-dot region signal indicating that the region constituting this large block is a halftone-dot region is output by the AND circuit 49. Similarly, in the image data shown in Fig. 4, there are 12 isolated points in the large block, and 'H' is output by the comparator 47. However, two of the small blocks (the small blocks ① and ⑤ in Fig. 4) contain no isolated points. Therefore, the values output by the OR circuit 48 include 'L'. Accordingly, regardless of the output result from the comparator 47, the AND circuit 49 outputs a halftone-dot region signal indicating that the area constituting the large block is not a halftone-dot region.

[0033] The processing executed by the halftone-dot determination unit 4 will now be described using the flow chart shown in Fig. 5. First, the total number of isolated points in the large block (hereinafter termed the 'total

isolated points') is initialized (S1). In this initialization, processing to divide the image data into large blocks and small blocks is carried out. The number of isolated points in any particular small block is then sought (S2). It is then determined whether or not the number of isolated points obtained in step S2 was '0' (S3). If the number of isolated points was '0' (YES in S3) it is determined that the large block is not a halftone-dot region (S7), and the routine ends. If the number of isolated points was not '0', on the other hand (NO in S3), the counted number of small block isolated points is added to the total isolated points (S4). It is then determined whether or not there are any other small blocks for which the number of isolated points has not yet been sought (S5). If other such small blocks exist (YES in S5), the operations beginning with step S2 are repeated regarding these small blocks. If no other small blocks exist, on the other hand (NO in S5), it is determined whether or not the total isolated points exceeds a threshold value (S6). If the total isolated points is larger than the threshold value (YES in S6), it is determined that the large block is a halftone-dot region (S8) and the routine ends. If the threshold value is larger than the total isolated points, however (NO in S6), it is determined that the large block is not a halftone-dot region (S7) and the routine ends.

[0034] The operation (S2) by which the number of isolated points is sought will now be described with reference to the flow chart of Fig. 6. First, the number of isolated points is initialized (S21). It is then determined whether or not the selected pixel is a pixel that displays an

isolated point (hereinafter termed an 'isolated point pixel') (S22). If it is an isolated point pixel (YES in S22), the number of isolated points is increased by one (S23). If the selected pixel is not an isolated point pixel, on the other hand (NO in S22), or after the operation of S23 is completed, it is determined whether or not other pixels exist in that small block as to which isolated point pixel determination has not been performed (S24). If such other pixels exist (YES in S5), the operations beginning with step S22 are repeated for such pixels. If no other such pixels exist, however (NO in S5), the routine ends.

[0035] Because various methods are known in the art for determining the existence of isolated point pixels (S22), details thereof will be omitted here, but it is acceptable if, for example, using a filter of  $3 \times 3$  pixels centered on the focus pixel, it is determined that the focus pixel is an isolated point pixel where the focus pixel is a black pixel and all of the pixels surrounding the focus pixel are white pixels. Furthermore, although in this example black isolated points are sought, the accuracy of halftone-dot determination is improved by seeking white isolated points as well. In determining the existence of white isolated points, it is acceptable if, for example, using a filter of  $3 \times 3$  pixels centered on the focus pixel, it is determined that the focus pixel is an isolated point pixel where the focus pixel is a white pixel and all of the pixels surrounding the focus pixel are black pixels.

[0036] The dividing unit 40 of this embodiment divides into small blocks the large blocks previously obtained via division, but it may instead first divide the entire

image data into small blocks and then aggregate the small blocks into large blocks. In this case, after the image data is divided into small blocks, areas of a certain size formed by contiguous small blocks are deemed large blocks.

[0037] The edge reproduction unit 5 performs smoothing based on halftone-dot region signals. The areas to which smoothing is performed are halftone-dot regions, and smoothing is not performed to other areas, i.e., character regions. The image forming engine 6 forms images based on the image data that underwent smoothing by the edge reproduction unit 5.

[0038] As described in detail above, in this embodiment, the image data input by the dividing unit 40 is divided into large blocks and small blocks. The number of isolated points in each of the various small blocks is then calculated by the isolated point counters 41-45. The adder 46 calculates the number of large block isolated points by adding together the number of isolated points counted by each of the isolated point counters. The comparator 47 compares the number of large block isolated points with a threshold value. The number of isolated points obtained by each isolated point counter is sent to the AND circuit 49 via the OR circuit 48. In other words, data indicating whether or not isolated points exist in each small block is sent. The AND circuit 49 determines that the large block is a halftone-dot region only where the large block isolated point total exceeds a threshold value and isolated points exist in each of the small blocks comprising the large block, and this result is output as a halftone-dot region signal. This is because the probability that the large

block is not a halftone-dot region is high where the large block includes at least one small block that contains no isolated points. As a result, erroneous region determination can be minimized. Therefore, an image processing apparatus offering minimal deterioration in output image quality can be realized by appropriately determining the attributes of each area within the image data and carrying out appropriate processing for each area.

[0039] This embodiment constitutes a mere example of the present invention, which is not limited in any way thereby. Therefore the present invention may naturally be modified or improved in various ways within the essential scope of the invention. For example, the image forming destination for the image processing apparatus is not limited to paper, and such image forming may be carried out on a display device such as a personal computer.

[0040] In this embodiment, the large blocks were formed with a horizontal orientation as shown in the drawings, but the present invention is not limited to this implementation. In other words, the large blocks may be oriented both horizontally and vertically. However, where the large blocks are oriented both horizontally and vertically, the burden on the memory and the processing system increases, and therefore it is preferred that they be divided in one direction only.

[0041] In this embodiment, the number of isolated point for each of the small blocks was sent to the OR circuit 48, but the present invention is not limited to this implementation. In other words, it is not necessary that the small blocks for which the isolated point totals are



sent consist of all small blocks or even contiguous small blocks. It is acceptable if areas that are away from each other in a large block are extracted for final halftone-dot determination. For example, it is acceptable if the small blocks ①, ③ and ⑤ are extracted from the image data shown in Fig. 3 and the number of isolated points for these small blocks only is sent to the OR circuit 48.

[0042] In this embodiment, the isolated point totals counted by the isolated point counters are sent to the AND circuit 49 via all of the OR circuits 48, but the present invention is not limited to this implementation. In other words, it is acceptable if a single 'H' signal is output when isolated points exist in all of the small blocks, while an 'L' signal is output when any small block does not contain any isolated points, and the AND circuit 49 outputs a halftone-dot region signal based on the signal output from the OR circuit 48 and the signal output from the comparator 47.

[0043] As is clear from the above description, according to the present invention, by appropriately determining the attributes of areas of the image data and executing appropriate processing with respect to such areas, an image processing apparatus offering minimal deterioration in output image quality can be provided.

[0044] Although the present invention has been fully described by way of examples with reference to the accompanying drawings, it is to be noted that various changes and modification will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present

invention, they should be construed as being included therein.